NASA TECHNICAL MEMORANDUM NASA TM-76009

HYPODYNAMIC AND HYPOKINETIC CONDITION OF SKELETAL MUSCLES

G. S. Katinas, V. S. Oganov and A. N. Potapov

Translation of "Gipodinamicheskoye i gipokineticheskoye sostoyaniya skeletnykh myshts," Fiziologicheskiy Zhurnal SSSR, Vol. 60, No. 10, 1975, pp 1606-1608

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 FEBRUARY 1980

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-76009		

4. Title and Subtitle	5. Report Date
HYPODYNAMIC AND HYPOKINETIC CONDITION OF SKELETAL MUSCLES	February 1980
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
G. S. Katinas, V. S. Oganov and A. N. Potapov	
	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
Leo Kanner Associates Redwood City, California 94063	NASw-3199
	13. Type of Report and Period Covered
	Translation
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, D. D. 20546	

15. Supplementary Notes

Translation of "Gipodinamicheskoye i gipokineticheskoye sostoyaniya skeletnykh myshts," Fiziologicheskiy Zhurnal SSSR, Vol. 60, No. 10, 1974, pp 1606-1608.

16. Abstract

Data are presented in regard to the effect of unilateral brachial amputation on the physiological characteristics of two functionally different muscles, the brachial muscle (flexor of the brachium) and the medial head of the brachial triceps muscle (extensor of the brachium), which in rats represents a separate muscle. Hypokinesia and hypodynamia were studied.

17. Key Words (Selected by Author)

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	7	

HYPODYNAMIC AND HYPOKINETIC CONDITION OF SKELETAL MUSCLES

G. S. Katinas, V. [illegible] Oganov and A. N. Potapov
First State Medical Institute, im. Pavlova, Leningrad and Soviet Health Ministry Institute for Medicobiological Problems, Moscow

One must distinguish two different conditions for the reduced activity of ske- /1606* letal muscles, hypokinesia and hypodynamia [4, 5, 8]. Hypokinesia is caused by restriction of mobility and is characterized by reduction of the number and scope of movements. Hypodynamia is induced by diminution of the power load. If each of these is to be analyzed one must look for methods that make it possible to differentiate the effects referred to [2, 4, 5, 7].

The present study provides data on the effect of unilateral brachial amputation on the physiological characteristics of two functionally different muscles — the brachial (m. brachialis), flexor of the forearm, and the middle head of the triceps humeral muscle (caput mediale m. tricipitis), forearm extensor, which in the rat is a separate muscle.

18 mongrel albino rats were subjected to left brachial amputation [5]. 18 intact animals served as controls. From 3 to 6 months following operation there was a weighing of the animals and of the muscles being studied under conditions of acute experiments in situ — time and force characteristics of single and tetanic responses of the brachial muscle and of the medial head of the brachial triceps in neuromuscular preparations of the operated and contralateral extremities of experimental rats and controls.

Amputation did not change the weight of the experimental animals. The middle head of the brachial triceps muscle weighed less than the contralateral by 27% ($p < 0.001$) and 33% less than the control ($p < 0.001$) (352±14, 341±16, 371±17 g respectively); the weight of the operated brachial muscle was the same as that of the contralateral and control: 254±10, 257±10 and 260±15 g respectively. The table shows physiological characteristics of the brachial muscles following forearm amputation.

---

* Numbers in the margin indicate pagination in the foreign text.

PARAMETERS OF SINGLE AND TETANIC RESPONSES OF SHOULDER MUSCLES TO BRACHIAL AMPUTATION

a Мышцы	b Характер ответа	c Время развития напряжения (мсек.)			d Время полуспада напряжения (мсек.)		
		e оп	f КЗ	g К	e оп	f КЗ	g К
h Медиальная головка трехглавой мышцы плеча	i Одиночный	38,4±2,8	37,6±2,9	35,2±1,9	38,9±2,8	35,6±2,2	40±3
	Тетанический	16,9±0,8	26,3±2,0	25,7±1,1	31±3	43±3	33,4±1,0
	j	$p = 0.01$			$p = 0.01$		$p = 0.01$
		$p = 0.01$					
k Плечевая i	Одиночный	24,6±1,9	24,8±1,7	24,2±1,4	26,3±2,3	20,5±1,7	18,8±1,3
					$p = 0.02$		
j	Тетанический	16,6±1,0	17,4±1,5	13,1±0,6	20,6±1,9	22,8±0,7	18,1±0,9
			$p = 0.01$			$p = 0.01$	
		$p = 0.001$					

m *Продолжение*

a Мышцы	b Характер ответа	n Амплитуда (г)			o Частота слитного тетануса (имп./сек.)		
		e оп	f КЗ	g К	e оп	f КЗ	g К
h Медиальная головка трехглавой мышцы плеча	i Одиночный	35±5	27,6±2,9	37±3	—	—	—
	Тетанический	109±16	172±17	199±11	90±3	78±3	85±4
	j	$p = 0.01$			$p = 0.02$		
		$p = 0.001$					
k Плечевая i	Одиночный	32±4	34±3	39±4	—	—	—
	Тетанический	232±23	173±19	241±20	111±4	97±4	122±3
j		$p = 0.05$			$p = 0.02$		$p = 0.01$

Remark: For tetanic responses time given is half that of stress development.

Key: a. Muscles.
b. Nature of response.
c. Stress development time (msec).
d. Half-life of stress.
e. Extremity operated upon.
f. Contralateral extremity.
g. Intact animals.
h. Medial head of triceps shoulder muscle.
i. Single.
j. Tetanic.
k. Shoulder.
m. Continuation.
n. Amplitude (g)
o. Rate of fused tetanus (imp./sec)

Earlier findings [5] as well as the results of the present study indicate, that a change in the weight of the shoulder muscles and disruption of their function following amputation of the forearm depends to a large extent on the degree to which they participate in maintaining vertical posture.

The middle head of the triceps, a flexor muscle, loses its antigravitational function following amputation and shows a real weight loss. Weight loss is substantially less or even nonexistent for the brachial muscle, whose function it is to produce phasic flexion of the elbow joint and has a slight antigravitational role [5].

Following amputation there were also differences in the muscles respecting the change in their functional condition. In the case of the operated middle head of /1607
the triceps muscle there was a diminution in the half-time of development of tetanic pressure and a drop in the amplitude of tetanic responses as compared with the same muscle in the controls. In the operated brachial muscle there was a lengthening of the half-time of development and the half-time of decay of the tetanic response, a drop in its amplitude and likewise a reduction in the frequency of fused tetanus as compared with the muscles of intact animals.

Unilateral brachial amputation likewise induced changes in the muscles of the contralateral extremity. In this case the middle head of the triceps muscle showed an increase in the half-time for reduction of tetanic pressure and a decrease in the frequency of fused tetanus, while the humeral muscle showed an increase in the half-life of single response pressure and the half-life of the tetanic response, a drop in its amplitude and also a reduction in the frequency of fused tetanus as compared with the muscles of intact animals.

The removal of the power load exerted upon the medial head of the triceps muscle induces in it a condition of hypodynamia. This state is characterized by a reduction of muscle weight, a decrease in the development time of tetanic pressure and a reduction in its amplitude. The combination of the two latter characteristics displays a qualitative analogy with the "force-speed" ratio described by Khill [9] for intact muscles contracting under different pressures. This ratio, which determines the mechnaical efficiency of the muscles, seems to be maintained under conditions of hypodynamia. The plausibility of such an explanation is borne out by a certain amount of data in the literature [6, 10-15]. /1608

Another condition develops in the brachial muscle of the operated and contralateral extremities. It is marked by a decrease in pressure development time and the time of its half-life and by a reduction in the fused tetanus frequency. Analogous changes were described in the muscles of animals kept for a long time under conditions of restricted mobility [1, 2-3, 7]. One may characterized the set of changes referred to as as hypokinetic condition. Here, in all probability, the nature of the "power-speed" ratio is changed. The difference between the hypokinetic condition and the hypodynamic seems to find its expression likewise in changes of a histochemical kind.

The more pronounced character of hypokinetic changes in the contralateral brachial muscle as compared with the operated brachial muscle may be associated with a reduction in its phasic activity, since the animal, after unilateral amputation, supports itself on the intact forelimb; there is also disruption of the synergic movement of the forelimbs. For similar reasons the contralateral medial head of the triceps brachial muscle also seems to be subject to conditions leading to the development of a hypokinetic condition. This is shown by an increase in the half-life time of tetanic pressure and a reduction in fused tetanus frequency.